# A Visual Landscape Assessment Approach for High-density Urban Development

*A GIS-based Index*

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**Keywords:** visual perception, visual quality assessment, urban planning, GIS

**Abstract:** The rapid developments of economy and urbanization bring great pressure to natural environment and resources, which contribute big challenge to sustainable urban development in high-density urban areas like Hong Kong, China and many other Eastern Asia cities. In these areas, protecting natural landscape resources and enhancing visibility to urban spaces and residential zones has become significant in improving the livability of human settlement. This paper presents a new approach in assessing the visual quality in high-density urban environment. The principal methodology is to quantitatively integrate human visual perception parameters with the visible landscape resources' characteristics. GIS is employed as the database and technical platform. A residential development in Hong Kong was used as a case study. The approach provides decision making support to urban planning, site layout design, and estate management during the early stage of the schematic design/planning process.

## 1 INTRODUCTION

The rapid developments of economy and urbanization not only bring great changes to the form and style of the urban sphere, but also challenge the natural environment and resources which support sustainable urban development in high-density urban areas like Hong Kong, China and many other Eastern Asia cities. Consider that for most people, natural landscape is usually more visually preferable than man-made constructions in urban environments (Kaplan 1983), beauty of urban natural landscape has the potential to improve the liveability of human settlement, or even enhance the estate value in market (Oh and Lee 2002). However, for years, the urban visual contexts of both Hong Kong and Chinese cities have been left ambiguous by the planning, design, management and real estate sectors. On the other hand, with the high urban density and its complicated construction patterns, new constructions usually yield fragmental views to landscape sceneries.

Many approaches intend to integrate urban landscape description, visual analysis and visual impact assessment have been developed to support planning decision making. For example, the frameworks for professionals by Blair (1986) and Moughtin et al (2003). However, several insufficiencies can be found in the decision making process in most of the current planning applications. Firstly, there is vagueness in the criteria of identifying the valuable landscapes that deserved to be protected. Secondly, there is no scientific tool which can provide satisfactory accuracy, efficiency, reliability, and validity to analyze and visualize relevant data. Therefore, the visual landscape protection premises, analysis and implementations are only based on personal experiences and manual operations, or even guessing and casual drawings.

To deal with these problems, a number of scientific landscape evaluation (LE) methodologies have been developed to provide quantitative description of natural landscape visual quality or impact prediction, and consequently, support the management of visual landscape resources in urban environment (Pogačnik 1979, Anderson and Schroeder 1983, etc.). There are also scientific systems established for development assessment which aims at achieving predefined subjective criteria like protecting important natural landscape resources. (Oh 2001). In these approaches, information technology (IT) and geographic information system (GIS) support are indispensable (Ervin and Steinitz 2003, Llobera 2003). However, most of these approaches are inadequate in terms of human perception (Llobera 2003). Oppositely, other research trends, such as the isovist studies (Batty 2001, Turner et al. 2001) applied in the urban visual study, are more concentrated on visibility and disregard the landscape resources which could be seen. The situation in high-density urban area is even more complicated. New construction not only changes the site's own configuration, but also possibly affects other area's visual perception, causes scenery blocking or disturbance. That is, the impact involves both the resource and perception qualities, which requires comprehensive consideration of urban visual resource and perception. However, efficient and accurate urban visual protection strategy is often difficult to be conducted in the very beginning stage of the schematic planning, so as design process based on recent urban visual assessment capabilities. An innovative GIS-based approach is therefore suggested. This paper presents its principal methodology and an implementation in a housing development.

## 2 CONCEPT OF THE METHODOLOGY

The principal methodology of this approach is to quantitatively integrate human visual perception characteristics with visible landscape resources to develop a visual quality assessment algorithm in order to evaluate the visual quality of urban vision. In the algorithm, the urban visual resources (R) are weighted by perception parameters through a model calculate the visual quality index (V) of a certain viewpoint.

$$P(R) = V \quad (1)$$

## 2.1 Visual Perception and Recourse Qualities

The research firstly investigates the perception parameters. The visual perception description is based on visibility (Ervin and Steinitz 2003). The resource quality, which means the kind of scenery which can be observed, is calculated based on an established LE model (Brown, Keane and Kaplan 1986). Then a combined visual quality value of a particular viewpoint is calculated to depict the comprehensive perception quality. The calculation is done through weighing the resource quality value within the visible scopes by relevant human visual structure parameters, such as visual distance, view angles, and so on (Higuchi, 1983),

In the proposed approach, this algorithm is introduced to build up an evaluation model which is based on the visual quality inventory of individual urban viewpoints. A single value is assigned to each viewpoint to interpret its visual perception quality. The value then forms an index of visual perception performance. Variations in indices of affected viewpoints or urban spaces can then be quantitatively compared to indicate the level of impacts in urban development. The same model is also used to predict the post-development visual perception.

## 2.2 GIS Support

GIS, coupled with computer technologies, has already led to great advances and become indispensable support in visual landscape analysis (Ervin and Steinitz 2003, Llobera 2003). In this research, GIS is introduced as a database as well as a technical platform. The following calculation and analysis is achieved through GIS operation.

- Viewshed: The viewshed of the studied viewpoints are calculated through 3D analysis. Several visual-related human engineering parameters are adopted in a GIS-based 360° panoramic visibility calculation (He, 2001).
- Landscape resource quality inventory: Landform (including the absolute value on the slope relative relief of a study cell and its spatial diversity relief contrasting the adjacent eight cells) and landuse (including the naturalism compatibility of a cell and its height contrasting internal variety by comparing with adjacent cells) (Brown, Keane and Kaplan 1986) are calculated and classified through spatial analysis.
- Assessment model implementation: Spatial analysis of GIS is employed in visibility calculation and model implementation. This analysis is applied in every study cell (size of 1m x 1m in most of the application) within the studied scopes. Visual quality of individual viewpoint or viewpoint groups in different selection strategies is counted into an index through cell statistics.

The data generated through the above-mentioned analyses are input in statistical procedures to evaluate the visual quality performance of viewpoint(s). Furthermore, GIS also generate maps for resource quality inventory, perception quality and visual quality indices distribution for each individual viewpoint or viewpoint group.

## 3 THE FIRST CASE STUDY

Through a case study collaborated with the Housing Department of HKSAR government, the research team conducted the first experiment of the proposed approach and explored the potential of this methodology. The case, Lam Tin Phase 7 Project, is a public housing development located between mountain and harbour sceneries. The objective of the case study is to assess the scenery blocking impacts of the proposed development to its neighbours, and then provide scientific data and visualization support for decision making of planners and architects.

### 3.1 Visual Quality Assessment

The methodology applied in this case study is illustrated in Figure 1. First, viewshed of specific study viewpoints is calculated with GIS software. The result is illustrated in an individual raster map in binary visibility (1 = visible; 0 = invisible) for each viewpoints. In this case, we only introduce visual distance, which is one of the most important visual perception parameters, and LE models (Higuchi 1983, Patsfall et al. 1984, Bishop and Hulse 1994; Batty 2001, etc) to interpret visual perception quality. The score of perception of each visible cell (denoted by P in the following equation) is assigned according to the classification of visual distance.

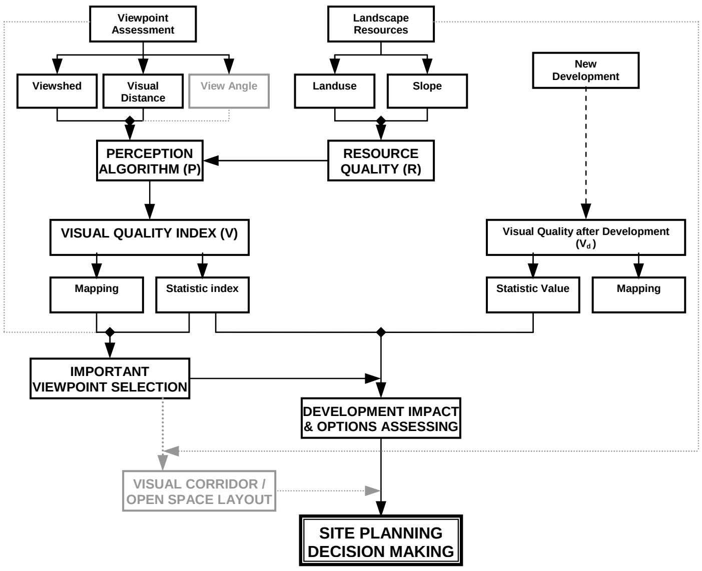


**Figure 1 System Framework of the Case Study**

$$\begin{cases} Visibility = 0, P\,(cell\ n) = 0 \\ Visibility = 1, P\,(cell\ n) = classification\ by\ visual\ distance \end{cases} \tag{2}$$

Simultaneously, the visual resource quality of the entire study area is recorded and classified based on landuse and landform (Brown, Keane and Kaplan 1986). The inventory is calculated from the data derived from aerial photos and land-band information, and classified into five categories (Figure 2). The scores of perception and resource quality are then combined through overlaying the calculation in each studied cell. In this case study, we equally weight the perception quality and resource quality in the algorithm (equation (3)). Therefore, every study cell which is visible from a certain viewpoint has its own integrated visual quality value from this viewpoint. These values can be mapped into a visual quality distributions (Figure 3) or counted into an index (expressed by statistical values in sum, average, or standard derivation) to interpret the visual quality of this viewpoint (Figure 4).

$$V\,(cell\ i) = R\,(cell\ i) + P\,(cell\ i) \qquad (3)$$

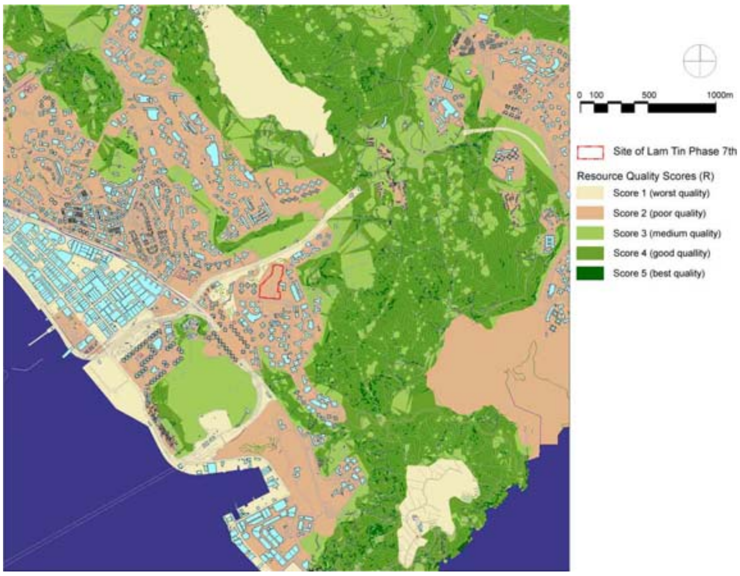


**Figure 2 Map of the Resource Quality Inventory**

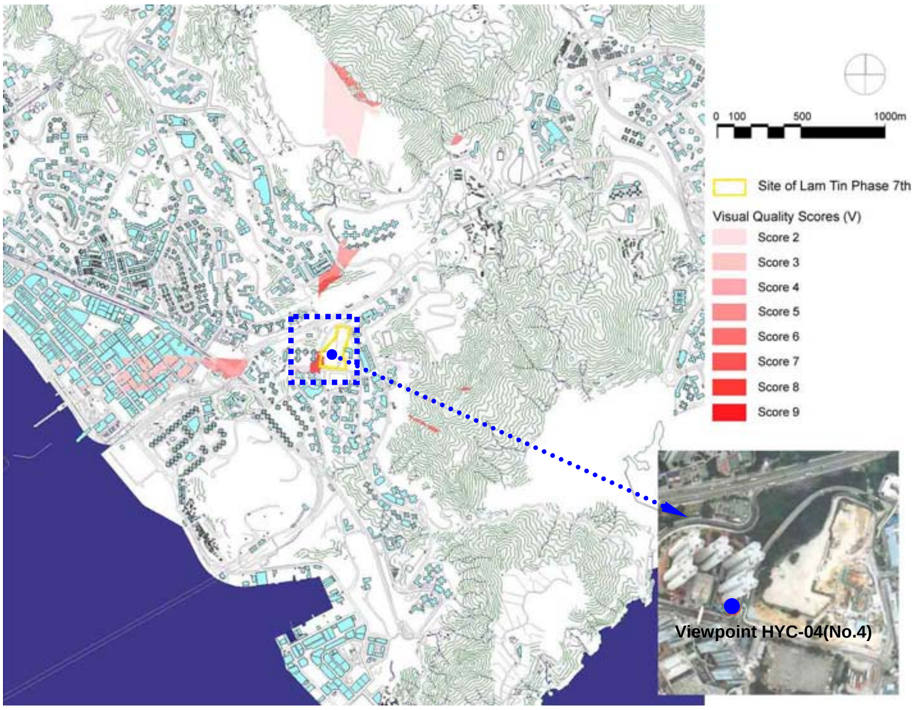


**Figure 3  Map of Visual Quality Distribution of Viewpoint HYC-04**

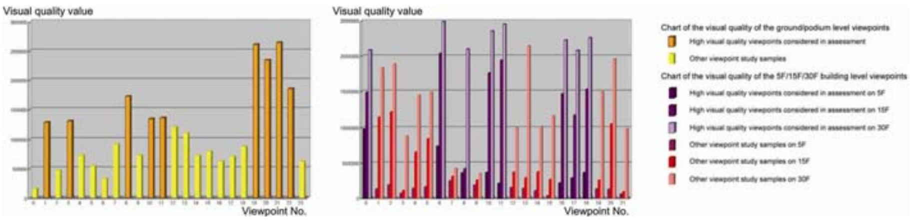


**Figure 4  Current Perception Quality Indices of the Studied Viewpoints (left: viewpoints on the ground/ podium level; right: viewpoints on 5/F, 15/F and 30/F of buildings)**

According to these indices, the studied viewpoints can be classified. Hence, planners, designers and managers can make further judgments on selecting significant viewpoints which deserves to be respected in future urban development (Figure 4).

## 3.2 Evaluation of Impacts to Surrounding Environment

Pursuing low negative visual perception quality impacts of the proposed development's neighbours is one of the key objectives in site planning. In this case study, four different site layout options are provided by the planners and architects. The research team compared their visual impact performance and illustrated the results through indices and charts. Planners and architects could also rely on this scientific data whenever the scheme selection requires balancing visual quality performance in multi-disciplinary aspects. In this study, we selected several key viewpoints which are either: 1. important spatial nodes of surrounding urban and/ or estate open spaces; or 2. typical viewpoints from flats at low (the 5th floor), medium (the 15th floor) and high level (the 30th floor) of the surrounding high-rise residential blocks. Each viewpoint's visual quality performance indices in the initial condition (without development) and those four layout options are calculated based on the above-mentioned methodology. On the other hand, a single visual performance value is also calculated for each design option, through summing up the visual perception indices of the surrounding studied viewpoints. The impact on the visual quality is then assessed by comparing either the sensitivity of individual index to the proposed development or the statistical value of viewpoint group before and after the proposed development. The visual quality value decline is illustrated by charts (Figure 5) or overlaid with thematic maps.

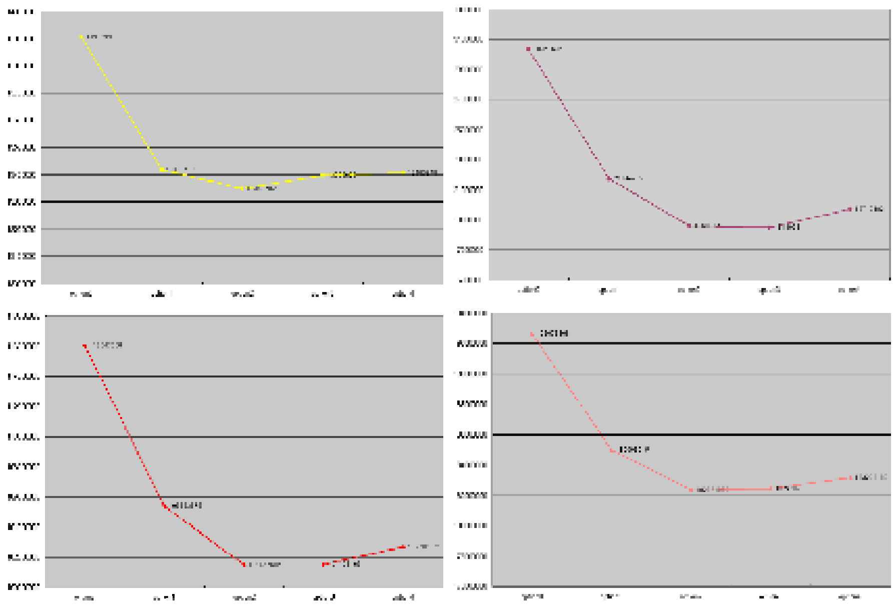

**Figure 5 Visual Quality Deteriorations with the Four Proposed Development (Expressed as Total Value of Studied Viewpoints on Ground Level (top left) and Building Levels of 5/F (top right), 15/F (bottom left) and 30/F (bottom right)**

From the comparison of visual quality deterioration trajectory, the layout plan with the minimum visual quality decline from the site's initial situation, i.e. lowest visual impact, is identified. In this case, the layout plan option 1 keeps a stable position of the least decline in order to sustain the visual quality. Furthermore, it can be seen that the visual quality deterioration trend in each diagram mostly coincides with each other. This also indicates the potential of validity to be applied in practical visual analysis (Tsou et al. 2004).

# 4 DISCUSSION AND FUTURE RESEARCH

The research in this case study is only the first experiment of the proposed approach. The aim is to explore the implementation potential in planning application. There are still spaces for further development in both the methodology and application aspects.

## 4.1 Methodological Improvement

The algorithm of perception is still far from mature in the current stage. Besides visual distance, other important parameters, such as incident angle, atmosphere perspective, physical intervening of land uses and elements (Higuchi 1983, Ervin and Steinitz 2003), should also be considered. Meanwhile, a more rigorous mathematical model should be developed in the upcoming studies. Future researches should introduce interviewers' measure in visual perception and regression analysis to verify the weighing of each variable in the equation. Field survey should also be conducted for validation. Another enhancement on the methodology relates to the viewpoint sampling. In this study, due to the limitation of computing resources, sample points are selected based on professional experiences of researchers. If there is enough number of viewpoints, a relatively more steady output could be generated. How to effectively locate the viewpoints for calculation is thus an important question to certify the evaluation results. One possible resolution is to locate the viewpoints in regular interval within the study region. Another approach is to define the scope in which the presumable development has significant impacts based on the principle of intervisibility.

## 4.2 Potential Fields of Application

There are also other potential application scopes for this methodology, for example, locating the visual corridors. Visual corridors which have potential to be maintained in future urban development can be mapped with high visual perception quality viewpoint(s) and high quality landscape resource(s). Moreover, the index can also be introduced to interpret the quality of flat views. The research team will simulate the mountains and sea sceneries of the living room window of every flat of the proposed residential development. The visual quality distribution on building façade will be surface-draped to a 3D model for visualization. Meanwhile, table and charts of these visual quality indices will also be employed as reference, which always only can be recorded after the construction in previous time. These data can provide more scientific and precise quantitative support for efficient decision making in design and estate management.

## 5 CONCLUSION

This paper describes a new approach of assessing visual quality that integrates visual resource and perception based on GIS operation. Its potential of managing visual resources for urban development and site planning is demonstrated. One thing should be pointed out is that we present the very earliest results of the implementation of this method and it have yet to be validated through further experiments and exploration.

The study and findings in this project have been reported to the government as well as the relevant professionals of this project including planners, architects and urban managers. We already received valuable comments, in which the sensibility and utility of the assessment method and index has been highly appreciated. On the other hand, incorporating more enriched considerations into the model algorithm was also suggested.

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